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BIOLOGICAL BULLETIN

NOTES ON PEDICULUS VESTIMENTI.

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The following notes are a curtailed record of two years' work on the body louse, when I was serving as a volunteer in the American Red Cross in Paris.

I undertook this work at the request of Dr. Alexander Lambert who was then at the head of the research department of the American Red Cross.

My reports were presented as contributions from the Foot and Strobell laboratory because a legacy left me by my friend Miss E. C. Strobell made it possible for me to give my entire time to the work and to pay the current expenses of my laboratory.

I am greatly indebted to the late Professor Blanchard for giving me space in his laboratory at the École de Médecine and for many other courtesies in connection with my work, and I am much indebted also to Professor Langeron, a member of Professor Blanchard's staff in the department of parasitology.

Although any official obligation to the Red Cross was ended when the research department was closed it has in no way altered my sense of obligation to continue my work with the hope of contributing some data that may serve in adding at least some control to the activities of the body louse, for this insect is nothing less than a curse not only to the armies but to those races which are forced to live under unsanitary conditions.

The first few months of investigation were necessarily devoted to a study of the life cycle of *Pediculus vestimenti,* an accurate and detailed account of which had already been published by several English investigators. Many years of experience in raising other species of Hemiptera led me to adopt slightly different methods of laboratory technique than those used by other investigators in their breeding experiments. These methods are de-

scribed in a recent note on the "Spermatogenesis of *P. vestimenti*" (Foot, '19).

It is impossible to breed lice without daily feeding them on human blood, and in the above mentioned note are stated the difficulties I encountered in finding a host. I finally secured the services of an old French sailor who came to my laboratory every day to allow them to bite his arm for one hour.

An amusing and perhaps significant behavior of the lice during the feeding hour was emphasized in my report to the research department of the Red Cross because it suggested a type of experiments that might be of some scientific value and needed the coöperation of a medical adviser. The old sailor (my food supply) was addicted to some drug—whether alcohol, absinthe, morphine or what not—it was impossible to determine, but the effect was unmistakable both on the sailor and the lice. The sailor slept the entire hour and the lice fought one another with apparent vicious intent. They showed no indication of seeking one another, but if two met while wandering restlessly about each would seize the other by the head and thorax, and claw with vicious activity, at the same time clinging with such tenacity that it was often impossible to separate them without injury to one or both. The combatants were either two males, two females, a male and a female or an adult and a nymph.

I learned later that this belligerent aspect of lice was appreciated by some of our soldiers and that a "cootie fight" in the trenches was one of the few recreations possible and afforded not a little amusement. Two sailors contributed each a cootie and they were placed on a small hand mirror, the ensuing combat been watched with keen interest and I suspect that the sense of proprietorship extended to the point of each owner betting on his own cootie. The boys thought the fighting spirit of the lice due to the fact that the two had been raised on different hosts, but I have tested this suggestion with negative results and I am inclined to think it merely an expression of some discomfort, due in the one case to the change from skin to glass and in the case of the old sailor it seemed to be a direct response to some abnormal condition of the blood. In this case it seriously interferred with my breeding experiments, for the lice not only injured

or killed one another but it prevented their feeding normally. When fed only one hour during the twenty-four, they (as a rule) feed the entire hour or stop only for short intervals—they pass each other and walk over each other without showing any mutual antagonism. The process was quite reversed in the case of the old sailor, for frequently, after feeding only five minutes, the fighting commenced and continued the entire hour. This phenomenon afforded not a little amusement in the laboratory and was unhesitatingly attributed to the sailor's blood, for to avoid the possibility of its being due to any foreign substance on the skin, the arm was always carefully cleansed over the area used for feeding.

In order to secure peaceful feeding it was necessary to place a single louse in each of the glass rings in which they were confined while being fed.[1] The above described curious effect of the abnormal blood of the host was not limited to the feeding hour, for the lice frequently attacked one another in the cages in which they were confined. Further, I found it exceedingly difficult to raise the young lice—they sometimes refused to bite at all and often died two or three days after feeding.

Being finally convinced that the blood of the old sailor was a

[1] In the above mentioned note on the spermatogenesis these rings and the cages are described as follows: "When feeding the lice I at first used the usual method of putting a number in a tube, inverting the tube on the arm and holding it securely in place to prevent the lice from escaping. I found this method unsatisfactory for several reasons and devised therefore quite a different technique: Lice cannot crawl up a glass surface if it is clean and are therefore perfectly safe in a glass ring even if it is only 2 cm. high. I had such rings made to order and fastened them securely onto the arm with melted paraffine (photo). In this manner several different experiments can be conducted at the same time and the generations can be kept separate—further the lice can be conveniently studied with a lens during the hour they are feeding. For the remaining twenty-four hours they were kept in a Pasteur incubator at a temperature between 27° and 29° C. While in the incubator the lice were kept in cages such as those used in the laboratory for raising various insects. This cage is the tube de Borel, in which is placed an inner tube for the insects, this being held in the center by absorbent cotton which is kept wet to insure sufficient moisture. I found the use of absorbent cotton very inconvenient and replaced it with a short tube having an aperture at both ends with a lip at each end sufficiently wide to center it in the tube de Borel. The inner tube in which the insects are kept is dropped into this shorter tube and an inch of water kept in the tube de Borel."

most unwholesome and even dangerous food supply and that my work was being seriously hampered by conditions I could not control, he was dismissed and exchanged for a mild old refugee from Chateau Thierry, who neither smoked nor drank. From that day I encountered no such difficulties in raising the lice. I could feed ten or more in a single ring and they fed together and lived together most amicably—the adults no longer attacked the nymphs nor did they attack one another.

After describing this phenomenon in my first report I concluded "These observations indicating that anything taken internally that may affect the character of the blood may also act directly on the louse suggest a line of experiments that might be worth trying and that I should like very much to undertake if I may be allowed the necessary guidance of a physician. The lice are so exceedingly fastidious in their diet, I would like very much to try the effect of certain drugs given to the host. If some simple drug can be found that when taken by a soldier will kill his lice or prevent their propagating it may be a helpful factor in combating the pest."[1]

A striking evidence of the sensitiveness of the lice to their food is the fact that although they will suck the blood of many animals they are not adequately nourished. Many investigators have attempted to feed them on animals and the results from these experiments are contradictory, authors differing as to whether the lice will or will not bite a definite animal. In the cases in which they have been induced to bite no evidence is given as to how long they survive.

In his classic work on *Pediculus* Nuttall ('17) has summed the evidence from experiments on the monkey, dog, rabbit, guinea pig, rat, mouse, fowl, pigeon and swallow—page 113.

My own experience has been that the lice will suck the blood of every animal I have tried but were not properly nourished, for they lived only a few days longer than under complete starvation; further the blood of the guinea pig as stated by other investigators is not only malnutritious but toxic for, as a rule, the lice die within 24 hours after feeding.

[1] I have recently learned that a French doctor conceived the idea of attacking the lice by this method but was unable to spare time for the experiments.

At intervals during a period of two years I have fed *P. vestimenti* on rabbits, guinea pigs, rats, mice, fowl, pigeons and canaries. In addition to feeding them on the blood of these animals I have tried to give them human blood by inserting a small piece of absorbent cotton under the most superficial layer of the epithelium of a young white mouse and dropping a few drops of fresh human blood upon the cotton. They bite the white mouse readily and get the human blood, as was shown by initial experiments with physiological salt solution stained with eosine—the colored solution in the alimentary tract demonstrating the possibility of their getting human blood by this method. A fresh mouse could be used each day, avoiding the possible criticism of the mouse itself becoming infected. Illness prevented my carrying these experiments to a satisfactory conclusion and I therefore do not know whether life can be much prolonged by this method. It however justifies further experimenting, for it should be of value in connection with those problems where it is imperative to keep the lice alive for definite periods after feeding them with infected blood. Further it should be of value in determining whether the lice themselves are infected, or whether the infection is confined to the blood in the alimentary tract, the latter acting merely as a mechanical transmitter. Many authors believe that this is the sole method of infection—scratching the bite and thus inoculating the victim with the feces of the louse being the sole danger—the bite alone being harmless. Nuttall ('17, page 61) quotes one experiment where a man was bitten by fifteen thouand lice which had fed on a relapsing fever patient and a second case in which a thousand lice were used. In neither of these cases was the host infected.

It is an established fact that the louse is the carrier of at least three diseases. It has been demonstrated for typhus fever by Nicolle ('09), Nicolle, Conte and Conseil ('10) and others. It has been demonstrated for recurrent fever by Sergent and Foley ('10), Sergent, Gillot and Foley ('11), Nicolle, Blaizot and Conseil ('12) and others.

It has been demonstrated for trench fever in the Report of the Medical Research Committee of the American Red Cross.

In addition to the above mentioned established cases lice have

been suspected of carrying nearly a score of other diseases. In view of the fact that the louse is not only a dangerous pest but that its bite causes subsequent effects that may be torture to the victim, the most imperative need is to persist in the search of a means of eliminating or at least limiting them, in spite of the many discouraging experiments which give only negative and disappointing results. Even a negative result may be of value to future investigators as one false step to be avoided and it is in this spirit that I have attacked the problem.

Innumerable experiments have been tried to make the host distasteful to the louse by various drugs applied to the skin or clothing but these have been so far from satisfactory that the most practical method at the front and elsewhere has been the bath and a complete change of clothing. This gives at least temporary relief, but to the poor victim who is sent back to the trenches it is of short duration. I have talked to many soldiers who have had sad experiences with *Pediculus,* and all appreciated the delousing methods in use but expressed the need of some method by which each soldier might individually control the pest even when compelled to live in their midst. I have often been impressed by the keen appreciation of our soldiers towards any effort to kill the "cursed louse." One amusing experience is worth recording. I had talked for nearly half an hour with two poor fellows who had just come from an area of the front which had no delousing outfit. They did not complain but merely stated how impossible it was to get an entire change of clothing and that a clean shirt one day and some other garment a few days later was a useless effort at delousing. They both had suffered greatly and were depressed at the thought of returning to the front the next day. They appealed to me for help and asked what experiments I was trying. When I told them I was experimenting with the hope of finding some drug that when taken by the soldier might make him distasteful to the cootie, one of the soldiers jumped to his feet exclaiming "My God! that is a good idea! what shall we take?"

So many investigators have experimented with the external use of drugs that it makes further effort seem almost hopeless and gives very little encouragement that the experiment of in-

ternal use of drugs may be of practical value though it may have scientific interest.

As stated above these experiments were suggested by the apparent direct response of the louse to the blood of the old sailor who was habitually under the influence of some drug. Further the toxic effect of the guinea pigs' blood and the non-nutrition of the blood of other animals led me to suspect it might be possible to find a drug that given to the host would make his blood distasteful or malnutritious to the lice, causing them to leave their victim, or it might be sufficiently injurious to the reproductive organs to inhibit multiplication. If the sperm or eggs can be injuriously affected this might prevent fertilization and so control the most effective phase of infestation. The danger from this cause is obvious from the fact that a single female lays about ten eggs a day[1] and as soon as these hatch (in five or more days) the nymphs begin to bite at once—feed during the day and night, and when mature (after about 20 days) the new life cycle begins. Thus the danger from a single fertilized female is apparent.

The mature insects, which are about 3 mm. long, can be easily found and as they are by no means active they can be readily caught and killed. The eggs and nymphs, however, cannot be so easily eliminated, for they are so tiny they may escape detection. It is obvious therefore that any offort made to inhibit or even limit reproduction is justified and worthy of patient experiment.

The first difficulty encountered was to find a host who would be willing not only to feed the lice but to consent to being drugged daily for at least a month as that was the period selected in order to determine any possible effect not only on the rate of reproduction but on the life of the nymphs as they may possibly be more susceptible to the food supply than are the adults. After finding a suitable host the experiments were conducted in the laboratory on a limited number of pairs of *P. vestimenti* and in order to detect any deviation from the normal a daily record was

[1] Nuttall, '17, page 130—"We may therefore conclude that under optimum natural conditions 275 or 300 eggs represent the normal number of eggs which a female is capable of laying and that during the greater part of her oviposition period she days 9 to 12 eggs a day or an average of 9.7."

kept of the behavior of the lice being thus fed on presumably medicated blood.

By this method three drugs were tested, Quinine, potassium iodid and sodium salicylate.[1] Of these three drugs quinine (which was suggested by Dr. Alexander Lambert) caused apparently the most abnormal response. As stated in my report "biting during the hour was less frequent and for much shorter periods. The nymphs were very restless, making frequent efforts to escape under the edge of the glass ring in which they were confined." I concluded my report as follows: "Although the lice do not bite normally and do not reproduce normally the toxic effect of the quinine is not sufficiently injurious to eliminate them. The most promising result is the very evident effort of the young nymphs to escape and in view of the well-known and persistent assertion that lice avoid some healthy people and leave hosts who have contracted certain diseases, it is possible that this effort to escape may indicate a distaste of the blood which may cause lice to leave a host who is taking quinine."

Potassium Iodid.—The experiment with this drug (appendix, p. 273) was less promising than the quinine experiment, the lice showing no desire to escape—they did however attack one another during the feeding hour, this presumably being an expression of some discomfort. The results from this experiment as stated in my report are as follows: "The only abnormal feature in the life history of two generations of lice was the marked tendency of the first generation to attack one another during the feeding hour. There is no evidence that potassium iodid taken by the host is either injurious or distasteful to the lice."

Sodium Salicylate.—The experiment with sodium salicylate (appendix, p. 274) was of interest merely because the sexes of the generation which was raised from four pairs of lice was most unequal, showing a very small proportion of males. These results would be of interest if the sexes are normally equal but this is an open question in view of Hindle's conclusions as to their normal variable inequality. Nuttall ('17) in giving a summary of the data as to the sexes says " the proportion of the sexes as determined by raising experiments have yielded contra-

[1] See appendix, page 272, for brief records of these three experiments.

dictory results," and this he thinks is due to the small broods of the experiments. This criticism justly applies to Hindle's results, whose conclusions are not convincing because they are drawn from broods which in no case reached 50 per cent. of a normal generation. The number of individuals in his 25 broods quoted by Nuttall are as follows: 2, 4, 6, 9, 9, 10, 11, 12, 15, 17, 24, 25, 26, 27, 29, 30, 31, 32, 34, 36, 38, 45, 48, 64.

Nuttall ('17) found the sexes nearly equal, though his broods also were small. My own results are in harmony with Nuttall's though I am able to give only one brood in evidence. In this one experiment, however, I attempted to determine the sex of every individual that was hatched and succeeding with 92 per cent. of a brood of 125 lice. This was made possible by using a slightly different method from that of other investigators. As stated in my report (Foot, '19), "Instead of waiting for the nymphs to mature in order to determine the sex they were dissected at any stage that was convenient and those that died were not discarded but dissected at once and their sex recorded." One hundred and twenty-five eggs were hatched and the sex determined for one hundred and fifteen (62 males and 53 females). Should repeated experiments with sodium salicylate show that the females *invariably* predominate we might then conclude that the drug is in fact more injurious to the males, for Hindle's broods were either all males, all females or males and females. If therefore a drug *constantly* effects one sex it must be injurious whether the sexes are normally equal per Nuttall or variably unequal per Hindle.

The most practical method of testing a drug and of testing the possibility of selection by the lice is to find a family where all the members are infested and to select one member for experiment. This is not as difficult as one would suppose, for there is a popular belief among the most ignorant class that lice are conducive to health—that their relation to disease is not only preventive but curative. These people, therefore, welcome them as friendly guests—a degree of hospitality it is difficult to understand. That this belief actually exists is proved by the fact that a generous bribe is needed to induce the host to face the possibility of any treatment causing his lice to decamp.

It is self-evident that this situation affords an ideal opportunity

for experiment and I have succeeded in securing the services of a young French doctor who has just commenced to practice and lives in a suburb of Paris where there is a large working class and where the popular belief as to the advantages of lice is in evidence. We are thus equipped to experiment not only with medicated blood but with the external use of drugs, which method of attack, however, has been so thoroughly tried and proved so disappointing that there is very little inspiration for further effort. I have repeated many of the experiments in the laboratory by applying the drugs on the area of the skin used in feeding and these efforts have only confirmed the negative results of other investigators.

I also experimented placing relatively impervious substances on the arm of the host to determine whether the lice would be aware of the human skin below and bite through the substance. One experiment was interesting as indicating that the lice realized the human odor. A piece of the skin of an apple was used and it was scraped until the layer was so thin it was almost transparent. After this was put on the arm of the host the lice were placed on it and showed no indication of being conscious of the proximity of the human skin—they not only showed no effort to bite but were indifferent and inert. After 30 minutes the apple skin was reversed and the surface which had been next to the human skin was placed uppermost. When the lice were placed upon this surface their behavior was entirely different—they were very active, running excitedly around in the confined area and this showing an indication of a sense of the human odor which undoubtedly adhered to the surface of the apple skin which had been for 30 minutes in contact with the arm of the host. The lice however showed no effort to bite through this foreign substance, though the experiment seemed to indicate that they are susceptible to an odor and is evidence in favor of the assertion that they avoid some people and that this selection may have some connection with a sense of smell.

I was fortunate in securing an opportunity to experiment with a case of this so-called immunity from attack by lice.[1] If we

[1] See appendix, page 274.

could find a genuine case of immunity, it is self-evident that a discovery of its cause might be of a great practical value.

The case I was able to study was that of an intelligent American soldier (Sergeant Du R.) from one of our Western States. He was thoroughly convinced that lice avoided him while attacking his companions with whom he was in close contact. As stated in my report he had been in France two years, was many months at the front and frequently exposed to the pest. He slept with his brother for about 3 months, during which period his brother was infested with *P. vestimenti* and suffered greatly. Later he slept for two weeks between two soldiers who were infested and the lice were also in the blankets. At no time was he bitten, nor did he find lice on his person, though he frequently searched for them.

In investigating his case my first disappointment was to find that the lice by no means refused to bite him, but apparently found him as tempting a host as any of the nine I had used in my breeding experiments. The next step was to attempt to find some explanation of his assumed immunity from attack. The first surmise was that he might be classed with those cases in which the bite is not followed by itching, and therefore he lacked the unmistakable evidence of their presence and was deceived as to his immunity. That explanation was quickly proved erroneous, for the itching from the bites was normal and very distressing.

A second search for an explanation was to test whether the lice could bite on all parts of Du R.'s arm, for if even a portion of his skin were abnormally thick it might give him at least some protection from attack. In my experience lice cannot bite through skin that is a bit callous, such as the distal end of the thumb and certain parts of the palm of the hand. Both adults and nymphs were fed on various areas of Du R.'s arm from the wrist to the shoulder and the biting was entirely normal in each case.

The two above mentioned suppositions could be easily tested but it was not possible to give a conclusive answer as to whether Du R.'s blood was sufficiently injurious to the lice to be offered in evidence of his claim that he was immune from attack and he

cannot therefore be listed as an actual immune case. As stated in my report "the death rate for the ten days feeding is certainly abnormally high. Of the 36 used for the experiment 26 died and as most of these died before the second moult and several died while moulting, the facts seem to indicate that Du R.'s blood does not nourish the lice normally but it does not warrant assuming that it adequately explains his apparent immunity." Unfortunately his case could not be further investigated as his duties called him from Paris.

I am now having a search made among the French families that are infested, hoping to find one in which a member is immune, for such a case would be a rare chance for experiment.

It is humiliating to admit that the above report of a two years' fight with *P. vestimenti* seems to leave the louse the victor, but this war is not over nor is there the impediment of an armistice for many earnest investigators are still fighting the pest and this encourages further effort.

Appendix.

The following reports were written for the American Red Cross while I was connected with the research department; as further experiments with drugs and also with so-called immunity are still in process the details of these reports may be of value for comparison with further results.

On the Reaction of Lice to Quinine in the Blood of the Host.

Host: Julienne F., age 30 years.

Quinine: Quinine sulphate. Prescription by Col. R. P. Strong. 15 grains daily.

No. of Lice: 3 ♂, 3 ♀, collected from a healthy woman at St. Louis Hospital, January 30, 1919.

Feeding: One hour daily. The above three pairs were kept from February 1 to February 12 and during that period were seen to mate six times. No. of eggs deposited, 69. No. of eggs hatched, 38 (55 per cent.). (Normally more than 75 per cent. of this generation are hatched.) Ten of the above generation fed one hour daily from February 13 to March 5 (21 days). Biting during the hour was less frequent than normal and for much shorter periods. The nymphs were very restless, making fre-

quent efforts to escape under the edge of the glass ring in which they were confined. (Normally they feed quietly and make no effort to escape.) After the first moult they fed much more normally. 2 died before the first moult. 1 died before the second moult. 3 died just after the second moult.

The remaining four had the third moult between March 1–4 (3 ♀, 1 ♂).

Eggs Deposited:

March 4th	1	
March 5th	3	
March 6th	6	
	10	(Illness of the host closed the experiment.)

Hatched: 3.

Results: Although the lice do not bite normally and do not reproduce normally the toxic effect of the quinine is not sufficiently injurious to eliminate them.

The most promising result is the very evident effort of the young nymphs to escape and in view of the well-known persistent assertion that lice avoid some healthy people and leave hosts who have contracted certain diseases, it is possible that this effort to escape may indicate a distaste of the blood which may cause lice to leave a host who is taking quinine.

The Reaction of Lice to the Blood of the Host who is Taking Potassium Iodid.

Host: Helen P., age 25 years.

Potassium Iodid: Saturated solution in water. Five drops three times daily. Prescription by Col. R. P. Strong.

No. of Lice: Four males and four females. Collected from healthy woman at St. Louis Hospital, April 2, 1919. The lice were fed one hour daily. Their behavior during the feeding hour was not normal. After feeding 10 or 15 minutes they fought at intervals during the entire hour, though they never apparently injured each other. The combatants were either two males, two females, or a male and a female. They seize each other by the head and thorax and it is frequently very difficult to separate them. After seven days feeding on the presumably medicated blood, the eggs were collected daily until 104 were de-

posited. The parent lice were then discarded. Seventy-five per cent. of the eggs hatched and forty of the nymphs were reserved to raise to maturity. These fed normally and showed no tendency whatever to attack each other, though twenty were fed in one small tube. A normal number reached the mature stage and the experiment was then closed.

Results: The only abnormal feature in the life history of two generations of lice was the marked tendency of the first generation to attack each other during the feeding hour. There is no evidence that potassium iodid taken by the host is either injurious or distasteful to the lice.

The Reaction of Lice to the Blood of the Host Taking Sodium Salicylate.

Host: Helen P., age 25 years.

Sodium Salicylate: Prescription by Col. R. P. Strong, 15 grains daily (5 grains 3 times a day).

No. of Lice: Four males and four females. Collected from a healthy woman at St. Louis Hospital, May 14, 1919. The lice were fed one hour daily. After seven days feeding on the presumably medicated blood, the eggs were collected daily until 159 were deposited. The parent lice were then discarded. Eighty-five per cent. of the eggs hatched and twenty of the nymphs were reserved to raise to maturity. Sixteen of these survived and after they reached the mature stage the experiment was closed.

Results: Only one possibly abnormal feature has been observed and the experiment must be repeated to determine whether it is due to the sodium salicylate. More than seventy of the F_1 generation were dissected for cytological study and a surprisingly small per cent. were males. After dissecting about thirty the following exact record was kept of the last thirty-nine dissected. Of these thirty-nine two only were males.

A Case of So-called Immunity to Attack from Lice.

There seems to be trustworthy evidence that many people are immune to attack from one or more species of insects that feed on human blood.

Nuttall ('17) gives the following data in relation to *Pediculus*

Record Showing the Proportion of Males to Females.

Date.	Stock.	Age.	Males.	Females.
6/15/19	29	7 days		5
6/18/19	"	" "		4
do.	"	Just after third moult		1
6/19/19	"	" " " "		3
do.	"	7 days		6
6/20/19	"	Just after third moult		6
6/21/19	"	" " " "		2
do.	"	8 days	1	
do.	"	7 days		3
6/22/19	"	Just after third moult	1	1
do.	"	9 days		3
6/23/19	"	Just after third moult		3
			2	37

vestimenti. He says Hase ('15) studied the effect of lice on behalf of the war office in Germany. He questioned one thousand persons on the subject and was able to place them under four groups. First, *persons who are not attacked by lice;* second, those who are attacked continuously and are sensitive to bites; third, those who are suffering from bites became immune to the effects; fourth, those who have been bitten continuously, but do not suffer from the effects. In group No. 1, he mentions a man who remained untouched by lice, but suffered from fleas. In group No. 2, a man who suffered from both lice and fleas. In group No. 3, a man who was bitten by lice but avoided by fleas.

It is frequently stated by people whose intelligence and accuracy of statement are beyond question that they are never attacked by a definite species of insect though surrounded by people who are infested by them. If such evidence is an accurate statement of facts, such facts merit careful scientific experiment not only to demonstrate their accuracy, but to search for the cause of the immunity. In the case of *Pediculus vestimenti* the practical value of such investigations is self-evident.

In June, 1919, I met in Soissons a very intelligent soldier who is convinced that *Pediculus vestimenti* will not attack him. Sergeant Du R., of Ohio, age 28, has been in France two years, was many months at the front and frequently exposed to the pest. He slept with his brother from February 15 to May 5, 1917, and during that time his brother was infested with *Pediculus vesti-*

menti and suffered greatly from the infestation. Du R. says he was never attacked at any time during that period and later he slept for two weeks between two soldiers who were infested and the lice were also in the blankets. During those two weeks he had no lice whatever, though he frequently searched for them. He kindly consented to allow me to experiment with his case and July 19, 1919, I took three young lice to Soissons for a preliminary test. My aim was to determine whether their behavior showed any abnormal features while they were on Du R.'s skin. At nine p.m. they were fed on a normal host and at ten p.m. they were placed on Du R.'s arm. Feeding one hour before the test eliminated the factor of intense hunger which might force them to bite a possibly distasteful host.

Result.—I could detect no abnormal features in the feeding. They bit almost at once and each fed at least twice during the fifteen minutes they were on Du R.'s arm. They were not restless, made no effort to escape, and were not combative.

Later this experiment was continued to determine whether the lice are not normally nourished by Du R.'s blood, whether biting is followed by itching, and whether selecting various areas on the arm would show that Du R.'s skin is abnormally thick. In my experience lice cannot feed where the skin is callous, for example, the distal end of the thumb or various places on the palm of the hand.

One naturally suspects that at least some cases of so-called immunity may be due solely to the fact that biting is not followed by itching. A case in point is that of a friend whose maid was infested with fleas, and Madame de B. expressed surprise that they had not attacked her also. Her maid replied "Madame is mistaken, for I found twelve on her underwear." This led to the discovery that she was bitten without being poisoned.

The following September, Sergeant Du R. came to the laboratory one hour daily for ten consecutive days and the lice were fed on various parts of his arm from the wrist to the shoulder. Those that died were dissected and their sex noted.

It was hoped these further experiments would conclusively answer the above mentioned three questions:

First—Is Du R.'s blood injurious to lice?

Second—Is biting followed by itching?
Third—Is there evidence that Du R.'s skin is abnormally thick?

Daily Record of the Experiment.

September 10: 33 lice were fed on the arm between the wrist and elbow. The lice varied in age, the older were between the second and third moult, and the younger before the first moult.

Behavior while Feeding.—All but one fed normally, showing no effort to escape, though they were slow in commencing to bite. The one that refused to bite Du R. was fed on a normal host four hours later and bit at once.

September 11: Three dead (all ♂ ♂). Added 3 just hatched (total 33).

Behavior while Feeding.—The 3 just hatched bit at once and fed normally. One of the older lot did not bite, for the digestive tube was ruptured. It was killed and dissected (a ♀). The remaining 29 fed normally.

September 12: Four dead. Three of the four died while moulting (3 ♂♂ and 1 ♀).

Behavior while Feeding.—One of the three that were hatched September 11 took scarcely any blood, the other two did not bite for fifteen minutes and then fed normally. One of the older lot did not bite, having moulted abnormally. The balance fed normally. The one that could not bite was killed and dissected (a ♀).

September 13: Two dead (both ♂♂).

Behavior while Feeding.—One of the 3 that were hatched September 11 did not bite and died a few hours later (a ♂). One of the older lot did not bite; it was therefore killed (a ♀).

The balance fed normally.

September 14: Three dead—one while moulting and one immediately after the second moult (2 ♂♂ and 1 ♀).

Behavior while Feeding.—One of the 2 hatched September 11 took very little blood and the other died on Du R.'s arm (a ♀).

The balance fed normally.

September 15: One dead. Died while moulting (a ♂).

Behavior while Feeding.—All fed normally.

September 16: Three dead before the second moult (1 ♂ and

2 ♀♀). They are full of blood and apparently normal, and this evidence that the blood is not digested is apparent in nearly all the lice that have died.

Behavior while Feeding.—All fed normally.

September 17: One dead (a ♂). He was full of blood and apparently normal.

Behavior while Feeding.—The older lot fed quietly but took scarcely any blood. The one hatched September 11 was very restless and took no blood.

September 18: Two dead (both ♂♂). They were full of blood and apparently normal.

Behavior while Feeding.—The older lot fed normally. The one hatched September 11 ran around for 45 minutes and then fed normally.

September 19: The one hatched September 11 is dead (a ♂). He had digested some of the blood taken yesterday and appeared normal.

Behavior while Feeding.—One did not bite, the balance fed normally.

Results.

The death rate for the ten days feeding is certainly abnormally high. Of the 36 used for the experiment, 26 died and as most of these died before the second moult, and several died while moulting, the facts seem to indicate that Du R.'s blood does not nourish the lice normally but it does not warrant assuming that it adequately explains his apparent immunity. The proportion of the sexes of those that died was 17 ♂♂ and 9 ♀♀.

The second question—"Is biting followed by itching?"—can be answered conclusively, for the itching was absolutely normal and very distressing. This proves that his immunity was not a case of being deceived by the fact that biting was not followed by itching.

The third question—"Is there evidence that Du R.'s skin is abnormally thick?"—can also be answered conclusively. The lice had no difficulty in drawing blood and even the nymphs just emerged from the shell, bit at once and fed normally. The lice were fed on various areas of the arm from the wrist to the

shoulder and showed no evidence of any abnormal effort in getting the blood.

A few smear preparations were made of the blood from the digestive tube; but showed no evidence of infection. The fact that nearly all the lice that died were full of undigested blood is the only evidence that Du R.'s blood is not normal.

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